Fertilizer Sources & Nitrogen Management

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“Two out of every five people on Earth today owe their lives to the higher crop outputs that fertilizer has made possible.”

– Bill Gates
Introduction

• Best management practices for reducing nitrate loading to groundwater must account for the properties of nitrogen fertilizers.

• Choosing the Right Source of nitrogen, in the context of Right Rate, Time and Place, will result in economically optimized and sustainable production.
Outline

• The Nitrogen Management Challenge
• Right Source Principles
• N Fertilizer Source Characteristics
• Conclusion
The Nitrogen Management Challenge

• N is nutrient most required by plants.
  – Plants respond visually to N applications.
  – Growers want their plants to be **GREEN**.
  – “Fertilizer” = Nitrogen fertilizer.
• Water and N are highly interactive.
  – Water drives transformations and losses.
  – N fertilizer has a direct cost **but**,
  – Water expenses are more indirect.
Economics & N Management

• Don’t apply enough N and water, lose yield.
  – For high value crops, risk is substantial.
  – Almonds @ $4.50 / lb * 100 lb = $450

• Over apply N and water and lose fertilizer.
  – N fertilizers at $0.50 - $0.75/lb N
  – N removal from 100 lb almonds = 6.8 lb N
  – 6.8 lb N * $0.75/lb N = $5.10
  – Return on Investment: > 80:1
Uncertainty of N Loss Calculations

• N Losses are based on mass balance.
  – Try to account for all inputs and outputs
  – But many unknowns and assumptions.
  – Currently, no simple method for measuring loss.

• N Removal is a $f$ (yield).
  – Difficult to estimate prior to harvest.
  – High variability within a management block.
Scientific principles for Right Source

• Consider
  – Other 3R’s: Rate, Time, and Place of application
  – soil physical and chemical properties

• Recognize
  – synergisms among nutrient elements and sources
  – blend compatibility
  – benefits and sensitivities to associated elements

• Supply nutrients in plant-available form

Adapted from IPNI 4R Plant Nutrition Manual Chapter 3
N Sources

- All N fertilizer starts as ammonia. (Haber process)
  \[ N_2 + 3 H_2 \rightarrow 2NH_3 \]
- Ammonia is pressurized and used directly, or converted to various solid and fluid fertilizers.
- Urea, ammonium and nitrate are most common.
- Each N Source behaves uniquely.
Source: Ammonium-N

- Anhydrous use decreasing
- Aqua (20-0-0) ammonium hydroxide solution
  - Still used in rice
- Most ammonia reacted with sulfuric, phosphoric or nitric to form fertilizer salts
- MAP, 10-34-0, ammonium sulfate, etc.
- All acidifying sources of N
  AMS >> MAP > 10-34-0 = UAN
Ammonium-N

- Root uptake by diffusion, not mass flow.
- Active uptake but fewer net calories.
- Roots export one $\text{H}^+$ for each $\text{NH}_4^+$ taken up.
- Microbially mediated oxidation of ammonium, nitrification, generates acidity.
- Seedlings and grasses utilize ammonium-N.
- Rice and blueberries need all ammoniacal-N
Source: Urea-N

- Two-step production reaction
  \[ 2NH_3 + CO_2 \rightleftharpoons (NH_2)_2CO + H_2O \]
- Most concentrated (46%) dry form of N.
- Half of most concentrated liquid, UAN-32.
- 150 Mtons consumed worldwide each year.
- 57.4% of total N fertilizer produced.
- Safe to handle
- Urea is compatible with phosphoric acid where UAN is not.
Urea

• Must be incorporated or watered in.
• Should not be applied with seed.
• Non-polar prior to hydrolysis.
• Hydrolysis takes place in 24-48 hours forming cationic ammonium ions.
• Volatilization losses
  – Most losses surface applied on warm, dry, sandy, high pH soil with a strong surface wind.
Urea and Fertigation

- Urea moves with water, similar to nitrate.
- When fertigating, apply ALL urea sources toward the end of long irrigation sets.
- Acidifier: 0.84 lb CaCO₃ / lb urea
- Following hydrolysis, ammonium cations are retained.
Reducing Urea Losses

- Urea stabilizers interfere with urease.
- Slow release polymerizes ureas.
- Controlled release coated with polyurethane.
- Products limit soil solution N concentration.
- Added cost per unit N but reduced losses.
- The right source may allow planting in sensitive areas.
• Produced by reacting ammonium with oxygen using a catalyst, then reacting with water to form nitric acid, HNO₃
• Nitric acid reacted with potassium hydroxide, calcium carbonate, or ammonia gas to form potassium, calcium and ammonium nitrates
• CaNO₃ mixed with ammonium nitrate to make CAN-17
• Urea mixed with ammonium nitrate -> UAN
Nitrate-N

- Immediately available for plant uptake.
- Ideal for cool soils.
- Moves by mass flow; passive uptake.
- Moves with the wetting front.
  - Must be applied toward the end of irrigation set
- Tends to slightly raise soil pH.
- Lower analysis and higher cost per unit N
- Larger caloric requirement for assimilation
Mixed N Sources

• Urea ammonium nitrate: extended feeding
  – Nitrate immediately available, followed by nitrified ammonium and urea
  – Urea and nitrate are BOTH mobile
  – An acidifier

• CAN-17
  – Maintains pH balance due to NO3:NH4 ratio
  – Soluble calcium flocculates soil, cation exchange
Source: Organic-N

- Mineralization must occur before organic-N is available for plant uptake.
- Mineralization rates depend on soil temperature, moisture, aeration, etc.
- Hard to align crop uptake with N release
- Organic sources are low analysis and bulky.
- Cost depends more on trucking.
- Well managed, improve soil quality & health.
Organic-N

• N source is not important once in the plant.
• Roots take up inorganic nutrients
• Nitrate is the same from fertilizer, manure, soil OM or water.
Making the Right Choice

• Ammonium sources
  – Soils with free lime and elevated pH
  – Acid loving and flooded crops
  – Warm, moist soil speeds nitrification

• Nitrate sources
  – Cool weather, drip vegetables
  – Low pH and low buffering capacity

• Blends, stabilizers, CRF, slow release
Making the Right Choice

• Organic sources
  – Organic certified production
  – Improve soil water and nutrient retention, tilth
  – Product is available locally and is of known quality

• Stabilizers, CRF, Slow release, etc.
  – Turf and ornamental
  – Environmentally sensitive situations
  – Potential for high losses
Conclusion

• Choosing the right source of N fertilizer depends on
  – the value of the crop,
  – price of the fertilizer,
  – soil physical and chemical properties,
  – method and timing of application,
  – environmental factors

• Don’t select fertilizer on price alone!